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# Proton Planning

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## Proton Team ("Finley Report")

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- Group formed in early 2003 to study proton demands and needs for the "near" future (through ~2012 or so), in the absence of a proton driver.
- Work culminated in a report to the director, available at [www.fnal.gov/directorate/program\\_planning/studies/ProtonReport.pdf](http://www.fnal.gov/directorate/program_planning/studies/ProtonReport.pdf)
- No big surprises [see P. Kasper "Getting Protons to NuMI (It's a worry)", FNAL Beams-doc-1036, 2001].
- This work will form the basis of "The Proton Plan".

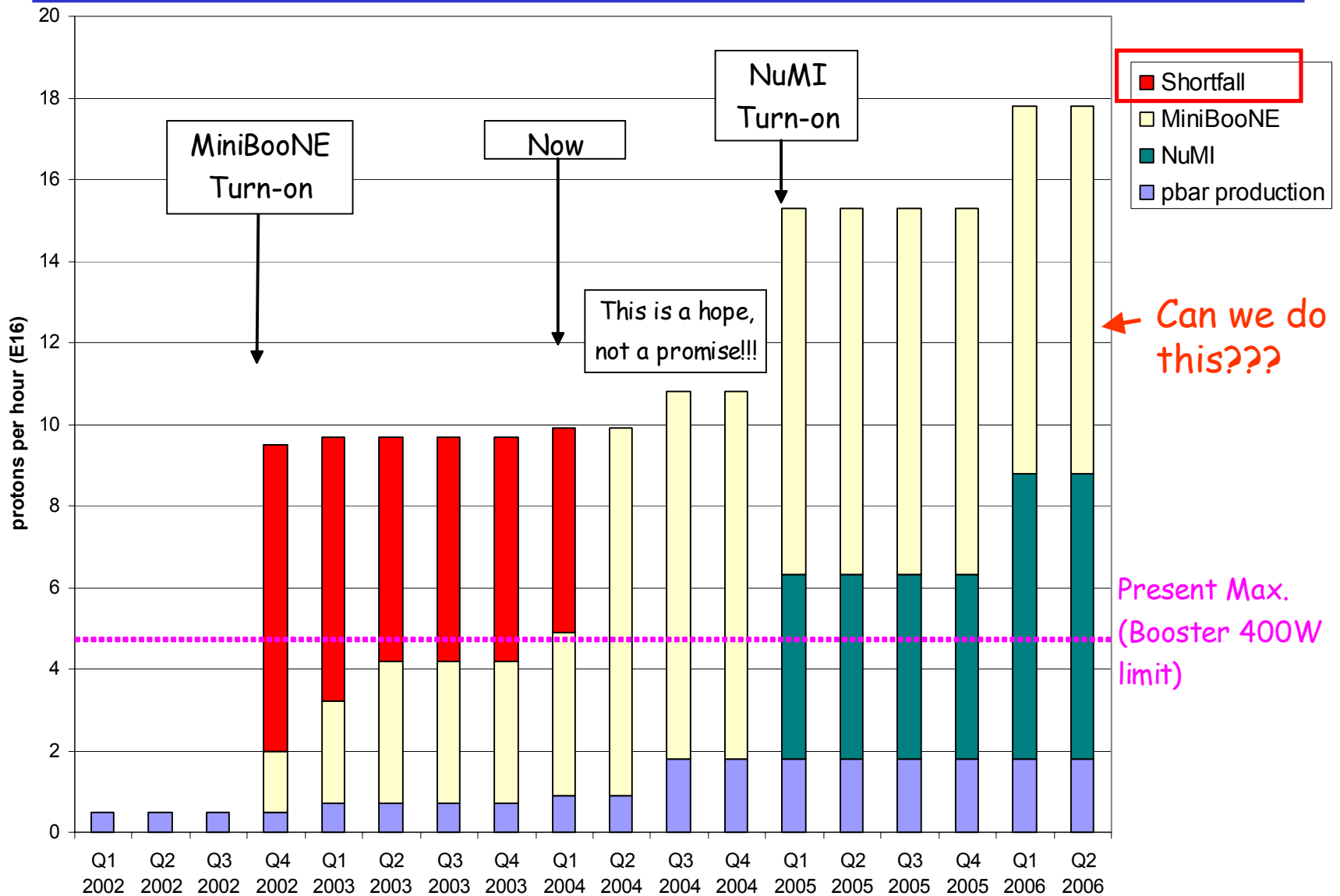
# What Limits Total Proton Intensity?

- Maximum number of Protons the Booster can stably accelerate:  $5E12$
- Maximum average Booster rep. Rate: currently 7.5 Hz, may have to go to 10 Hz for NuMI+ (full) MiniBooNE
- (NUMI only) Maximum number of booster batches the Main Injector can hold: currently 6 in principle, possibly go to 11 with fancy loading schemes in the future
- (NUMI only) Minimum Main Injector ramp cycle time (NUMI only): 1.4s+loading time (at least  $1/15s * nbatches$ )
- Losses in the Booster:
  - Above ground radiation

➤ Damage and/or activation of tunnel components

*Our biggest worry at the moment!!!!*

# Proton Demand



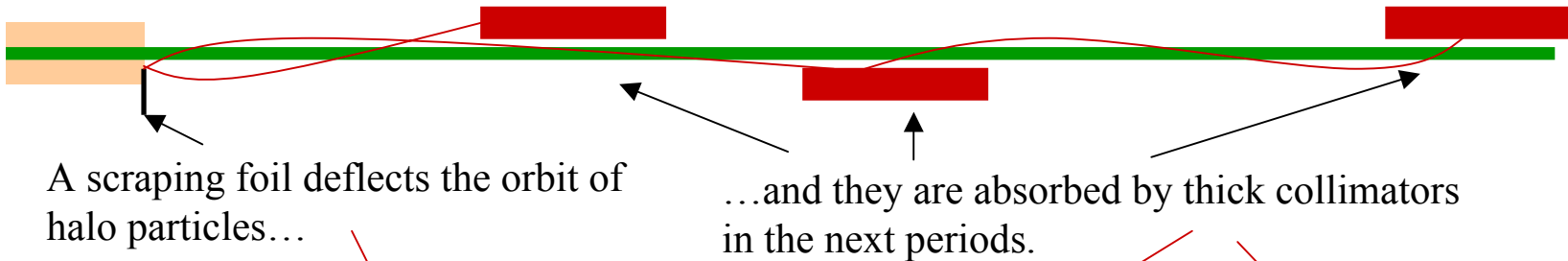
## Projects in 2003 (a short list)

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- 2003 Activities centered around preparation for the September shutdown:
  - Linac water system upgrade
  - New Linac Lambertson
    - Better optics in 400 MeV line
  - Booster two-stage collimation system
    - In the works a long time
    - Now in place.
  - Major modifications at main extraction region
    - Address “dogleg problem” caused by extraction chicane system.
  - New, large aperture magnets in extraction line:
    - Should reduce above-ground losses
  - Major vacuum system upgrade.
  - Lots of smaller jobs.

# New Collimator System

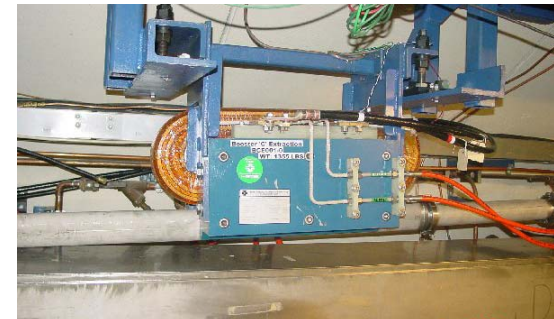
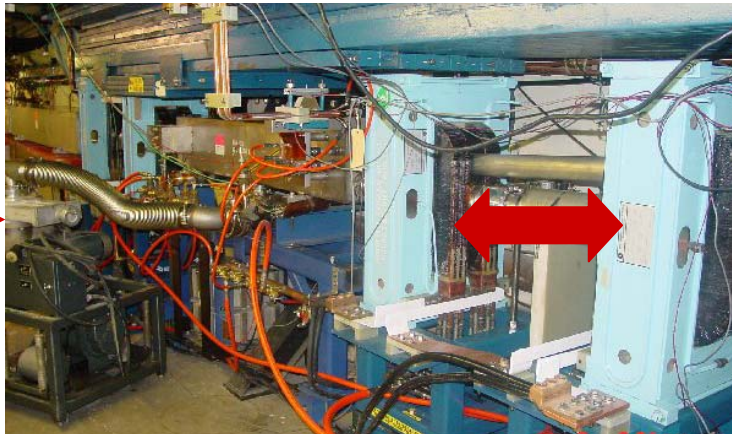
Basic Idea...



- Should dramatically reduce uncontrolled losses



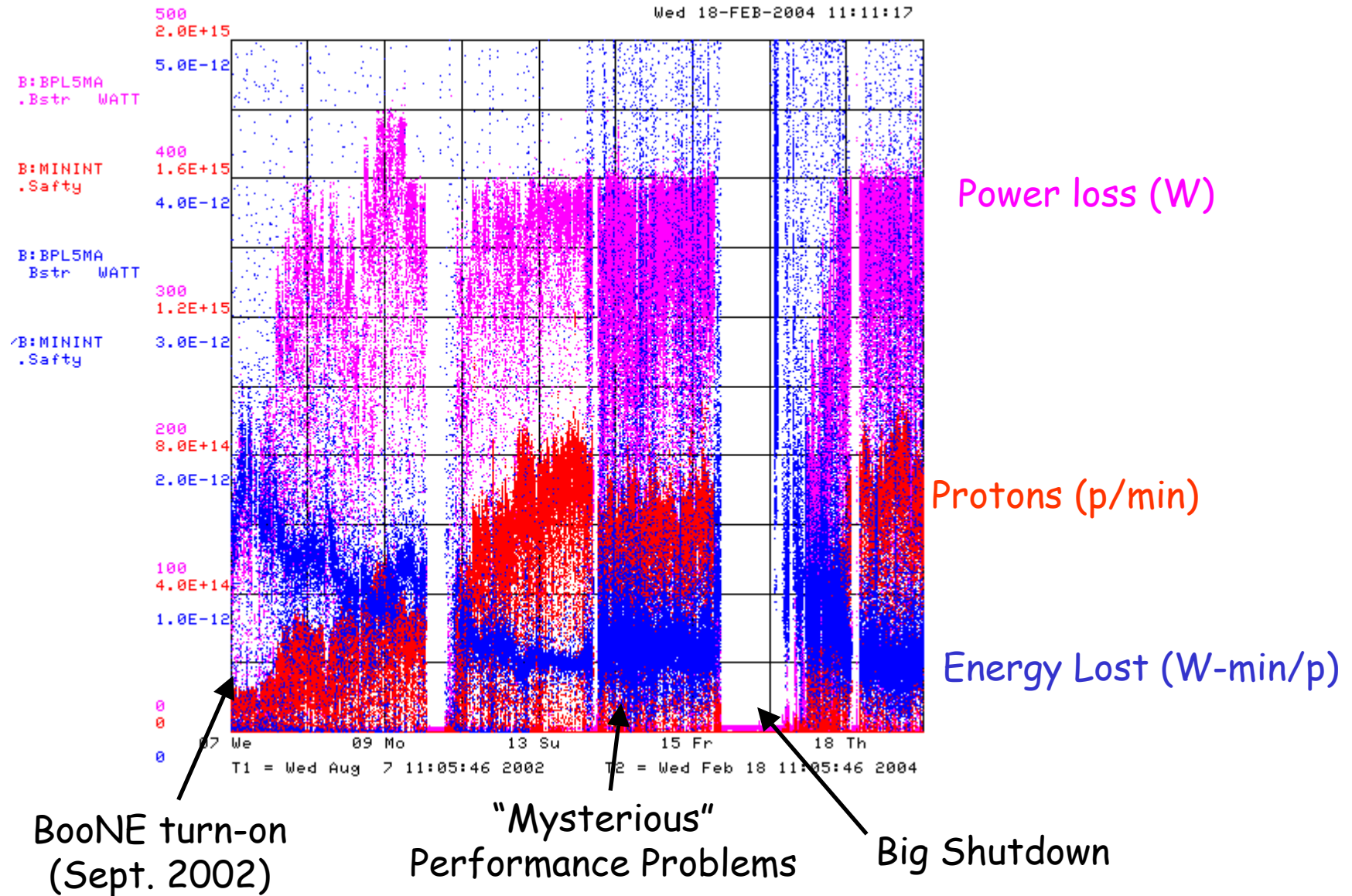
# Long 3 Dogleg Work



New magnet to match  
extraction line

- Increase spacing between dogleg pairs from 18" to 40" to reduce lattice distortions at injection.

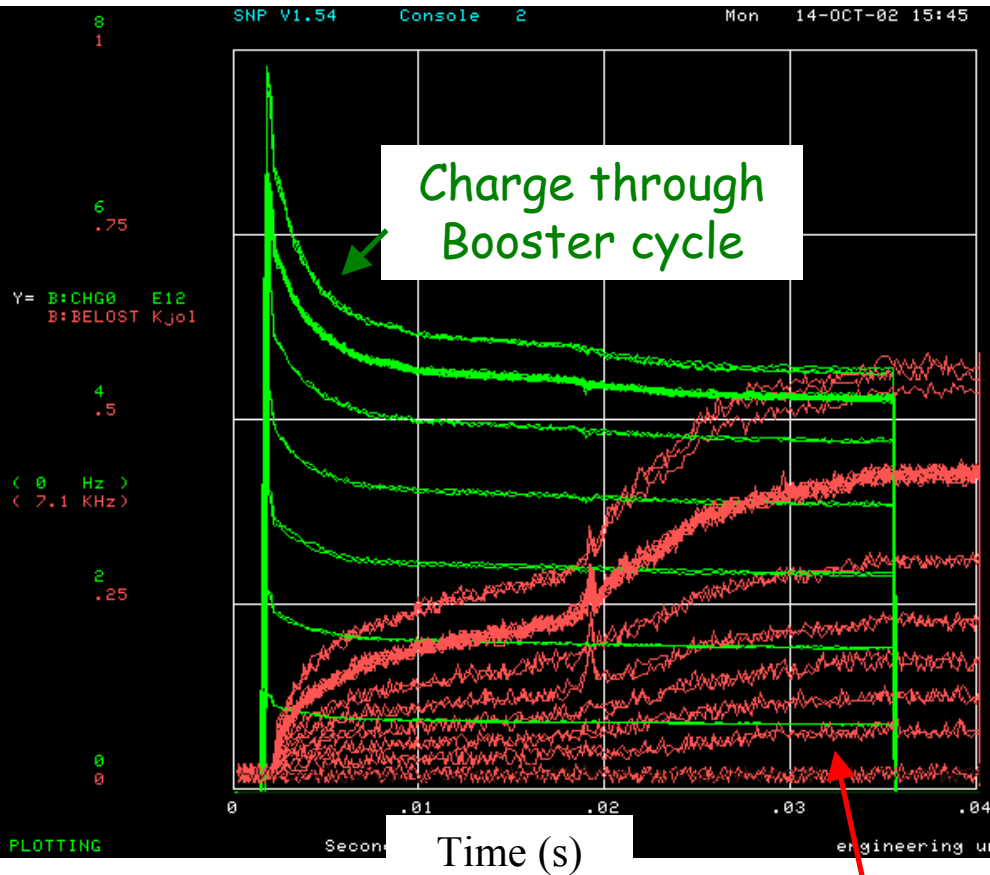
# How are We Doing?





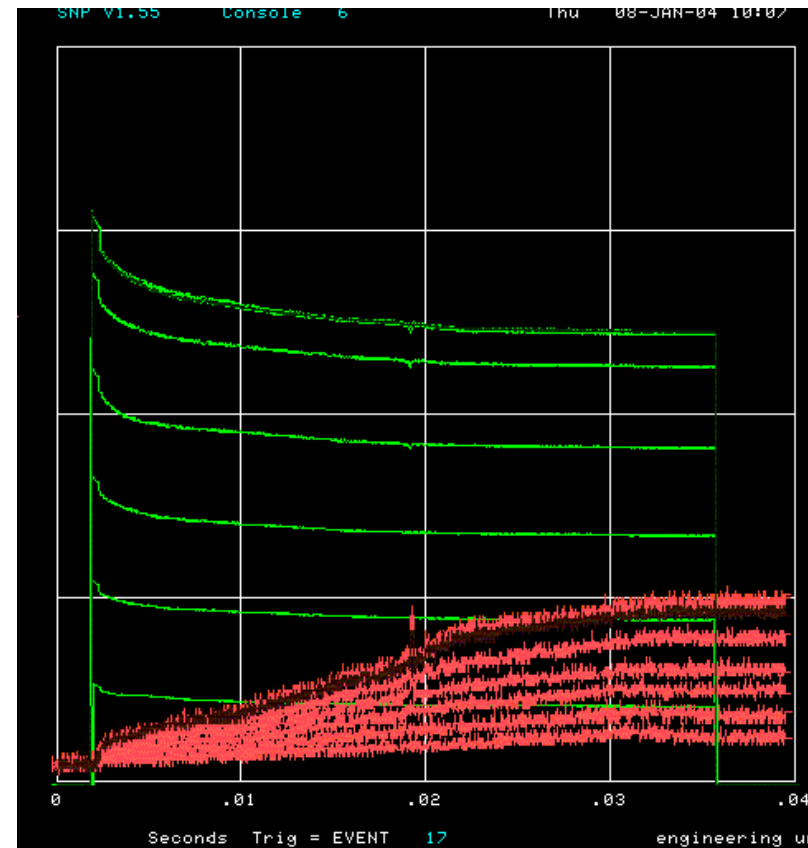
# How far have we come?

Before MiniBooNE



Energy Lost

Now (same scale!!)



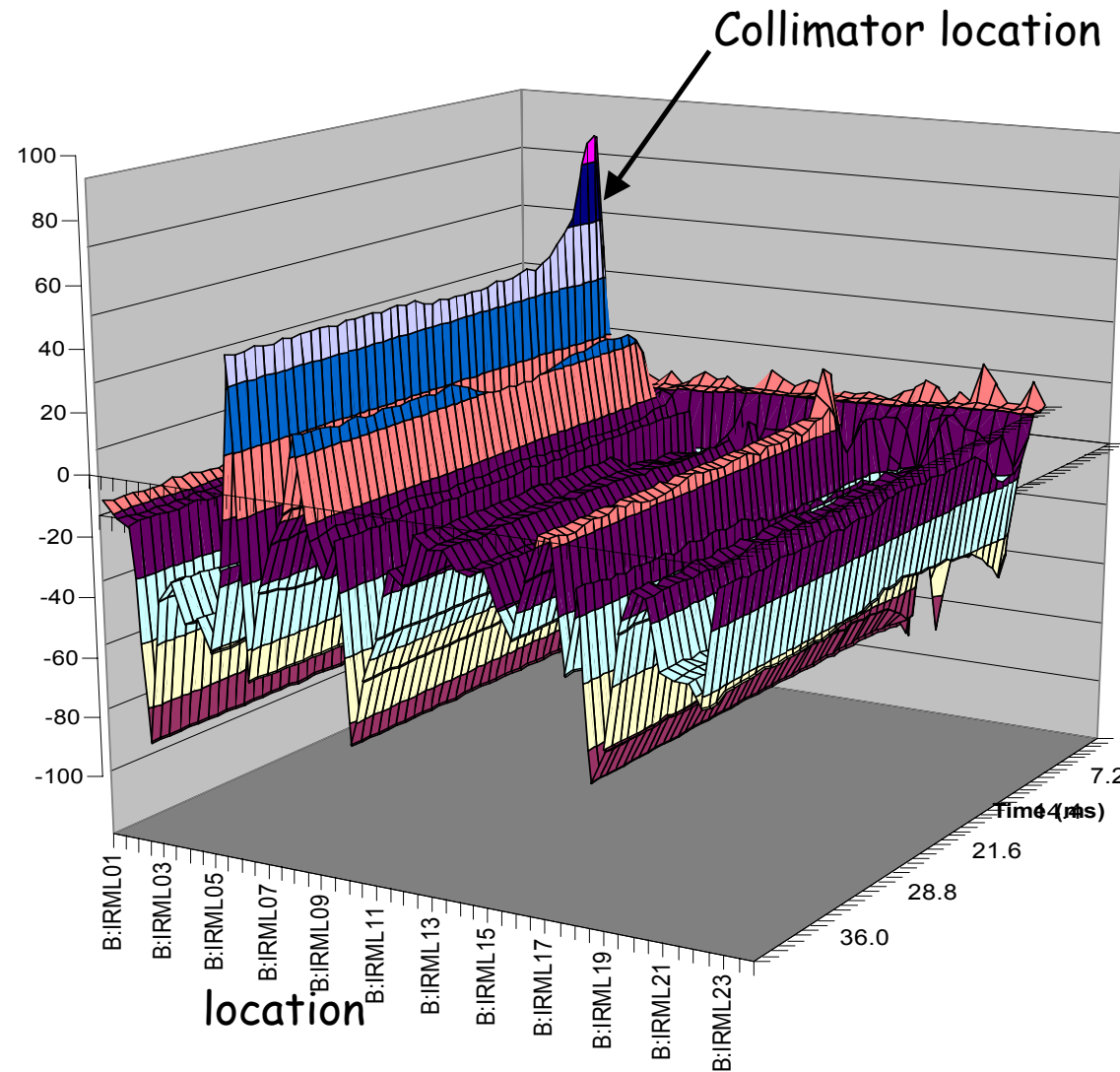
Note less pronounced injection and transition losses

# Near Term Priorities (Booster)

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- Optimizing Booster for improved lattice:
  - Tuning and characterizing 400 MeV line (Linac to Booster).
  - Tuning Booster orbit to minimize losses.
- Commission Collimators:
  - Estimate another month or so to bring into standard operation. (discussed shortly)
- Aperture Improvements:
  - Alignment (discussed shortly)
  - Orbit control
    - Abandoning our original global plan in favor of local control at problem spots for the time being.
  - Prototype RF Cavities
    - Two large aperture prototype cavities have been built, thanks to the help of MiniBooNE and NuMI universities.
    - We will install these as soon as they are ready to replace existing cavities which are highly activated.
- Multibatch timing: Beam cogging

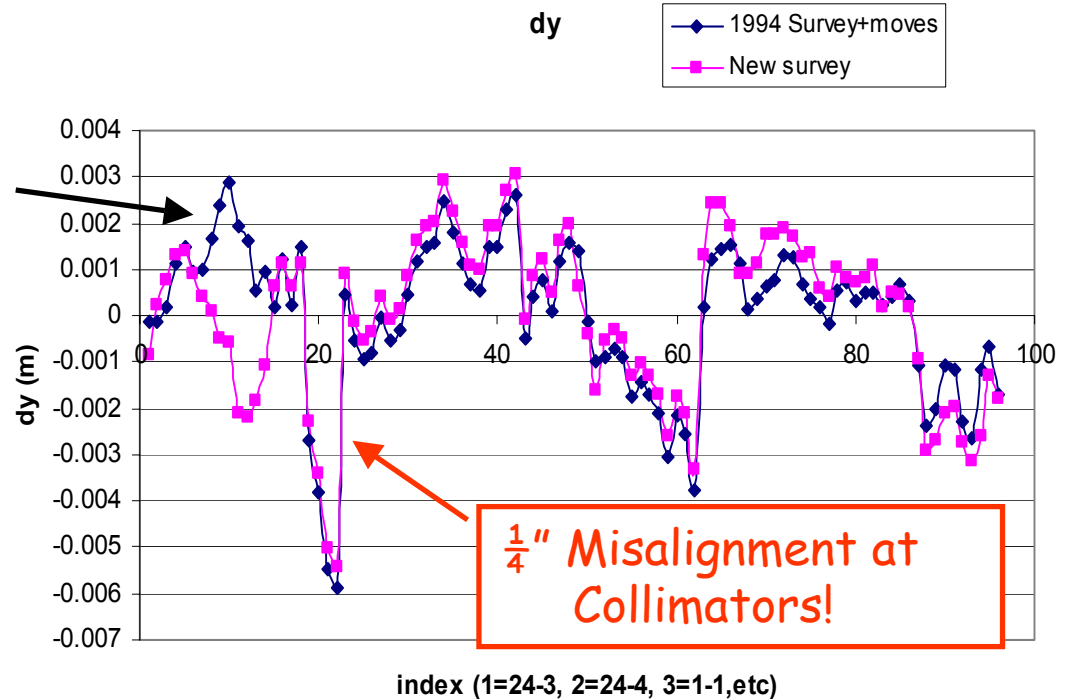
# Collimator Studies



- Shown is the effect of putting in one of the secondary collimators as a percentage change in losses as a function of time around the ring.
- Studies are continuing.
  - "Rapid response team" will be put on problem.
- At present, primary collimators are not optimized to energy loss profile
  - Will replace in upcoming shutdown.

# Alignment Problems

Effect of Booster  
tower shielding



- Working closely with AMG
- As opportunity allows
  - Fix vertical orbit
  - Align RF cavities
- Over the next year
  - Complete network
  - Integrate with MAD
  - Make a horizontal plan.

# Priorities over the Next Year

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- Linac Characterization and Reliability
  - Increase instrumentation of old linac to study instabilities.
  - Develop set of performance parameters.
- Booster improvements.
  - Prepare for modification of second extraction region
    - New septum
    - Modified dogleg magnets
    - On track for next year's shutdown.
  - Injection bump (ORBUMP) improvements:
    - Injection Bump (ORBUMP) Power Supply
      - Existing supply a reliability worry.
      - Limited to 7.5 Hz
      - Building new supply, capable of 15 Hz.
      - Aiming for summer shutdown (aggressive, but doable)
    - New ORBUMP Magnets
      - Existing magnets limited by heating to 7.5 Hz
      - Working on a design for cooled versions.
      - These, with a new power supply, will make the Booster capable of sustained 15 Hz operation.
      - Aiming for summer shutdown (aggressive, but doable).

# Planning for the future

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- In response to the "Finley Report", the lab management has asked for a "Proton Plan" for the proton source over the next few years, analogous to the Run II plan, but much lower in scope.
- The plan is to do what we can reasonably do to maximize the throughput and reliability of the existing proton source (incl. MI), under the assumption that a Proton Driver will eventually be built.
- Beyond the things I have already mentioned, the scope is largely determined by the budgetary guidance:
  - FY04: \$0-2M
  - FY05: \$6M
  - FY06: \$5M
  - FY07: \$5M
  - FY08: \$2.5M



## Comment on the Budget

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- This budget is more than enough to do the basic things that we must do to keep the proton source going, provided some of it appears this year!
- It *precludes* certain ideas that have been suggested:
  - New Linac front end, or any significant 200 MHz upgrade.
  - Decreasing the Main Injector ramp time
- There are some “big” (>\$1M) projects that must be discussed.

# Large Projects Under Consideration

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- **Booster RF system:**
  - Commission a design for a new booster RF system
  - Larger aperture, higher gradient cavities
  - Solid state distributed amplifiers
  - Goal to have design by January 2005.
  - Two year timescale to build and install (perhaps solid-state DA's can come sooner).
  - Cost ~all of it.
- **Adding two additional cavities**
  - Use university prototypes + spare parts
  - Cost ~\$500K
- **New corrector packages for the Booster**
  - Trim dipoles + quads
  - ~\$3M
- **30 Hz harmonic to booster ramp.**
  - Effectively increases RF power
  - Cost of order \$1-2M
- **New LEL quad power supplies.**
  - A significant reliability worry
  - Cost of order \$1M.

## Schedule for the Plan

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- Will proceed with the vital projects for this year.
- Hope to have a skeleton of a plan by the end of this month.
- Will have a more detailed plan and major recommendations by this summer.

# Expectation Management

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- What we really think we can achieve:
  - Slipstacking to provide  $1\text{E}13$  protons per pulse for pbar production.
  - $5\text{E}20$  protons to MiniBooNE by the time NuMI fully comes on in early 2005
  - $2\text{-}2.5\text{E}20$  p/yr to NuMI in the first year of operation.
  - Increasing that over the next few years, to something over  $3\text{E}20$  p/yr.
- What we might achieve:
  - Continuing to operate the 8 GeV line at some significant level *after* NuMI comes on, ultimately delivering  $1\text{E}21$  protons to MiniBooNE and possibly supporting other experiments (e.g. FINESSE).
  - Delivering as many as  $4\text{E}20$  p/yr to NuMI, at which point things will be limited by Main Injector aperture and cycle time (with the present source, anyway).
- It would be unrealistic to believe:
  - We will ever send more than  $4\text{E}20$  p/yr to NuMI without significant ( $\sim \$100\text{M}$ ) investment in the existing complex.
  - That would be direct competition for resources with the current Proton Driver proposal.